UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS

Operations Guidance Report on

WATER FACILITIES FOR ELM CREEK WATERSHED TEXAS

Prepared by

WATER UTILIZATION SECTION
DIVISION OF LAND ECONOMICS

July 1939

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Under the Provisions of the
Water Facilities Act
(Public Law No. 399, 75th Congress)

July 1939

AUTHORIZATION

This report has been prepared in accordance with the provisions of the Water Facilities Program authorized under the Water Facilities Act, Public Law No. 399, 75th Congress.

The Elm Creek watershed in Uvalde, Kinney, Dimmit, Zavala and Maverick counties, Texas, was approved for "area planning," with operations authorized to proceed therein as rapidly as mutually agreed upon by responsible field officials of the Soil Conservation Service, Bureau of Agricultural Economics, and Farm Security Administration, except that no operations shall be undertaken which involve development of additional underground water, by the Water Facilities Board, at Washington, D.C., on January [illegible], 1939. Formal notification of the Board's action is contained in Texas State Memorandum No. 3, dated January 19, 1939.

ACKNOWLEDGMENTS

Published and unpublished data of the United States Geological Survey, Bureau of Soils, and Texas Agricultural Experiment Station have been referred to freely and have provided invaluable basic information for this report. The Humble Oil Company has been most liberal in contributing geological information essential to the report. County Agricultural Agents, of the counties within the area, have given liberally of their time and information to facilitate the compilation of various agricultural data. Complete cooperation by members of the field staff of the Soil Conservation Service and Farm Security Administration, the operating agencies in the area under the Water Facilities Program, has expedited the preparation of this report. Industrial engineers of the Central Power and Light Company have graciously contributed technical data on cost, installations, and efficiency of irrigation pumping plants in the district.

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SUMMARY

This report, which must be considered as preliminary, presents (1) a physical description of the area, (2) a discussion of the present use of the land and water resources of the area together with some comments concerning the institutional and general economic characteristics, and (3) a statement concerning future utilization of the area.

The area is characterized by low precipitation, and soils and climate adaptable to grazing and truck crop production. Supplies of ground water sufficient for domestic and livestock purposes are available in parts of the area. The eastern portion of the area is underlaid with the Carrizo sands from which water is obtained for pump irrigation. Very little dry land farming is practiced.

There are two principal types of farming in the watershed; namely, ranching and truck crop, which are highly significant from the standpoint of area planning. Practically all of the area is operated as large cattle and sheep ranches. A small portion of the watershed near Carrizo Springs, Crystal City, and La Pryor is irrigated for highly specialized vegetable production. Salt water has been entering the irrigation wells which has adversely affected

production and which may seriously affect the economy of this section of the area. The situation is such in this portion of the watershed that it is impracticable at this time to make definite recommendations concerning water facilities used for pump irrigation. It is recommended that repairs to the irrigation wells be deferred until a comprehensive study of the irrigated portion of the watershed, which will involve considerably more time than was available for the preparation of this guidance report, is completed. Water facilities recommended for domestic and livestock purposes and for flood irrigation, on the other hand, should be installed as rapidly as possible.

In subarea 1 domestic and livestock supplies should be obtained from wells which recover water from the Edwards limestone. Where adequate supplies are encountered above this limestone, these supplies should be utilized. In this subarea stock tanks may supplement wells as the initial cost of a tank is less than that of a well. In subarea 2 adequate supplies of potable ground water are scarce and surface water storage tanks are recommended. Subarea 3 includes the Carrizo sands and wells for domestic and livestock purposes only are recommended at this time. These wells will not materially affect the existing ground water supply.

INTRODUCTION

Purpose and Scope

The purpose of this report is to present the significant physical features of the Elm Creek Watershed which will serve as a means of determining existing maladjustments apparent within the area, and to propose a plan which will serve as a basis for adjustment through the proper utilization of both land and water resources.

Due to the complexity of the area, the lack of available data, and the limited time available for its preparation, this report must be considered preliminary. Livestock ranching and truck crop farming constitute the principal types of farming in the area and also roughly distinguish the principal physical, economic, and institutional problems encountered in planning the area. This report includes information concerning the physical characteristics of the entire watershed. Explanation of the economic and institutional characteristics of the watershed is limited to the ranching area as these characteristics of the vegetable area are complicated and will require considerably more time to plan than was available for the preparation of this report.

Estimate of Reliability

The base map accompanying this report has been compiled from tactical quadrangle sheets of the Corps of Army Engineers and from

quadrangle sheets of the United States Geological Survey, supple-
mented by data from aerial photographs in parts of the area, and by field investigation. Large parts of the ranching portion of the area are inaccessible to automobiles. The drainage as mapped is considered sufficiently accurate for all practical purposes. That of the northern and southern portions of the area has been checked with aerial photographs. Only a few roads, tanks, and wells have been located in the field. The remainder have been taken from other maps and descriptions, the accuracy of which has not been determined.

The included geological map is an enlargement of the United States Geological Survey's geological map of Texas. It is accurate only in a general way and cannot be relied upon for the exact location of formation contacts. The base map employed was inaccurate and the geological information shown thereon for this area is largely compiled rather than mapped. The included well records and analyses are regarded as very reliable.

Surface water discharge records are not available for points within the area. The record for the Nueces River gage at Uvalde is not considered entirely applicable for the area due to the nature of the cross-sectional area of the river at this point. This and other discharge records have been taken from United States Geological Survey Water Supply papers. The analyses of these records and the expectancy rating curves are somewhat speculative, and represent only estimates of probable maximum discharges.

Climatological data as supplied by the United States Weather Bureau and the Idaho Agricultural Experiment Station at [illegible] Haven appear to be thoroughly reliable and adequate.

Agricultural data regarding range conditions are limited and on farming and ranching practices inconclusive.

The information in this report is necessarily general since much of the area is still in a rather primitive state. Records and studies are either completely lacking or in process of compilation.

IV

PHYSICAL DESCRIPTION OF THE AREA

Location and Size of Area

The Elm Creek Water Facilities Project covers that area of southwestern Texas which lies approximately between parallels 28° 30' and 29° 20' north latitude and meridians 99° 30' and 100° 25' west longitude and its area is approximately 1,403 square miles or 897,920 acres. The watershed is defined in this report as that part of the Elm Creek drainage above Caimanche Lake. This lake is connected with Espantosa Lake which drains into the Nueces River. The area includes parts of southwestern Uvalde, western Zavala, northwestern Dimmit, eastern Maverick, and southeastern Kinney counties.

There are no towns or cities within the area, but several small towns are closely adjacent to the area. On the southeastern side of the area are located the towns of Carrizo Springs with a population of 3,200, county seat of Dimmit County, about seven miles from the area; and Crystal City, population 7,100, county seat of Zavala County, about four miles east of the area. On the northeastern side about 12 miles east of the area is the town of Uvalde, county seat of Uvalde county, population 6,300. About two miles west of the northwestern part of the area is Bracketsville, population

2,200, county seat of Kinney County. The town of Spofford, population 100, is located in Kinney County on the western boundary of the area. Eagle Pass, population 6,500, county seat of Maverick County is located on the Rio Grande River about 10 miles southwest of the area.

The Elm Creek watershed presents a great variety of physical characteristics as well as of land and water utilization. Topography, drainage pattern, land slopes, and stream gradients exhibit great diversity over the area. Numerous geologic formations and soil types exist in the area. Ground water varies extremely as to depth, quality, and quantity. Precipitation is torrential in character and poorly distributed through the year. Run-off and peak discharges are abnormally high. Summers are long and hot, and winters short and mild. In general, the area may be described as characterized by prevailing extremes and lacking in uniformity.

Physiographic Location of Area

The Elm Creek watershed lies in the Rio Grande Embayment in the extreme northwestern part of the Gulf Coastal Plain physiographic province. This province extends in a northeast-southwest direction between the Gulf of Mexico on the south and the Balcones fault zone which forms the southern boundary of the Edwards Plateau province on the north.

[illegible]

Topographically, the Elm Creek drainage basin can be divided into two distinct provinces by the east-west county line separating Kinney and Uvalde counties on the north from Maverick and Zavala counties on the south.

The Anacacho Mountains extend about 15 miles approximately in an east-west direction across the southwestern part of this northern division of the watershed and form the most significant topographic feature. These are, in reality, a series of low rocky hills rising 400 feet or less above the surrounding terrain. North of the Anacacho Mountains is a belt of less hilly relief rising gently to the north and averaging about 10 miles in width. Immediately north of this belt, hilly relief again becomes prominent. Las Moras Mountain, elevation 1,867, Elm Mountain, elevation 1,642, and Turkey Mountain, elevation, 1,806, appear as peaks in this region. Turkey Mountain and Las Moras Mountain are located on the divide between the Elm Creek and Nueces River drainages which mark the northern boundary of the area.

In this northern portion of the area land slope gradients are comparatively high ranging from less than 1 per cent to 20 per cent. Elevations rise from an average of about 950 feet at the southern boundary of Kinney County to an average of about 1,400 feet at the northern boundary of the watershed.

The southern topographic province consists of a southward to southeastward sloping plain of gently undulating to low relief, dissected by southeastward flowing streams. Surface elevations drop gently from about 850 feet at the east-west county line south of Kinney and Uvalde, and north of Maverick and Zavala counties to an average elevation of about 600 feet at the southern end of the area. Elevation also drops from about 800 feet in the southwestern part of the area near Eagle Pass to a low of about 570 feet in the vicinity of Caimanche Lake near Crystal City at the southeastern corner of the area. In the southeastern part of the area where bayou-like conditions exist land slopes are very small.

Most of the land in Maverick, Zavala, and Dimmit counties within the area is comparatively level to gently rolling with the exception of that which is immediately adjacent to the streams where the topography is frequently rough.

The Elm Creek watershed presents many unusual and distinctive characteristics. It lies between two major drainages; namely, the Rio Grande River on the west and the Nueces River on the east and north. Elm Creek eventually becomes a part of the major Nueces river drainage basin. It is a typical example of stream piracy since the minor Elm Creek now has diverted the drainage of a large area, formerly drained by the Rio Grande River, to the Nueces River drainage. The Elm Creek drainage is young and poorly developed as typified by the bayou-like conditions of Caimanche Lake at the lower

end of the watershed. None of the streams in the area are perennial. Throughout the upper part of the watershed the drainage pattern is dendritic, but toward the lower end some trellis pattern exists and the drainage is poorly defined.

From east to west across the watershed the following major creeks appear; Turkey Creek, Chaparosa Creek, Live Oak or Blanca Creek, Elm Creek, Mustang Creek, and Rocky Creek. In the upper portions of the basin tributaries of these streams have been given various names, some of which appear on the base map, but among local people there is considerable disagreement regarding their nomenclature. Chaparosa Creek is probably the largest and oldest of the streams in the area, though Elm Creek is the longest stream and has the largest drainage area. Turkey, Live Oak, and Mustang Creeks do not extend into the hilly sections of the area. Otherwise the physical characteristics of the streams are very similar. The stream channels are narrow with steep banks particularly in the upper part of the area. Stream gradients vary from one or two feet per mile at the lower end of the area to over 100 feet per mile at the upper end of the area on Turkey and Elm creeks. Through the central area the gradients of these streams average about 10 to 15 feet to the mile, while those of smaller tributaries are considerably higher.

Natural Vegetation

In the northern part of the area, having comparatively rough topography, the vegetation consists of grasses, weeds, and shrubs.

About 45 per cent of the total vegetative cover is composed of grasses, 12 per cent of weeds, and 43 per cent of shrubs.

In the central and southern region where the topography is rolling to flat and better soil types prevail, the vegetative cover consists of grasses and weeds.

There is considerable variation locally in both type and density of vegetation. In a general way the vegetative cover may be characterized as a light to dense growth of low thorny shrubs, small trees, cacti, forbes, weeds, and grasses. Many of the small trees are legumes.

Climate

There are no Weather Bureau stations in the Elm Creek watershed, but climatological records have been maintained at Uvalde, La Pryor, Carrizo Springs, Eagle Pass, and at Fort Clark at Brackettville. These stations are all near enough to the watershed to give a good picture of the climatic conditions which prevail in the area.

The winters in this portion of Texas are mild, but occasionally "northers" occur which send the temperature below freezing. These cold spells are of short duration, rarely lasting over a period of three days. The summers are long and hot. The temperature is frequently above 100°, but drops rapidly after sunset making the summer evenings cool.

Rainfall in this section is unevenly distributed throughout the year and is usually torrential in character. Snow rarely falls in the area but hailstorms are not infrequent.

Table 1 gives the average number of days with .01 inch or more of precipitation, the average, average maximum, average minimum, and the highest and lowest temperatures at the above mentioned stations.

The average dates of the first and last killing frosts and average length of growing season are given below:

	Average Date of Last Killing Frost	Average Date of First Killing Frost	Average Growing Season
Uvalde	Mar. 13	Nov. 21	253 days
La Pryor	Feb. 27	Nov. 27	273 "
Carrizo Springs	Feb. 26	Dec. 6	283 "
Eagle Pass	Feb. 27	Nov. 26	272 "
Fort Clark	Feb. 26	Nov. 27	274 "

Evaporation records are very recent and are available only for 1931 at Winter Haven. These data in inches are as follows:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1.5	2.2	4.8	5.6	4.9	6.3	6.9	7.1	7.3	5.8

Nov.	Dec.
3.8	1.7

- a total of 55.8 inches during the year.

The prevailing winds in this area are from the south and southeast though during the winter winds from the north are frequent.

TABLE 1

PRECIPITATION AND TEMPERATURE DATA FOR UVALDE, LA PRYOR, CARRIZO SPRINGS, EAGLE PASS, AND BRACKETTVILLE, TEXAS.

Uvalde, Texas
25-year record

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Aver. No. of days with .01 inch or more precipitation	3	3	4	5	5	4	4	3	5	4	3	4	47
Average temperature	53.1	51.4	64.5	70.8	76.9	82.8	85.0	84.9	80.3	71.7	61.1	53.4	70.2
Average maximum temp.	67.3	72.4	78.9	84.5	89.4	95.2	97.8	99.0	93.7	85.9	75.0	66.3	83.8
Average min. temp.	39.0	42.9	49.9	57.2	64.4	70.3	72.3	72.5	68.1	58.2	49.1	40.1	57.0
Highest temperature	90	100	100	104	107	114	110	110	106	102	98	91	114
Lowest temperature	10	14	20	27	40	55	61	59	41	23	17	15	10

La Pryor, Texas
15-year record

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Aver. No. of days with .01 inch or more precipitation	7	5	5	5	6	5	5	3	5	6	6	6	64
Average temperature	51.2	56.6	63.0	70.2	76.9	82.9	84.8	85.2	79.8	70.7	59.7	52.2	69.4
Average maximum temp.	63.2	69.9	76.7	83.5	89.3	95.0	97.1	98.0	91.8	83.2	71.9	64.8	82.0
Average min. temp.	39.2	43.3	49.3	56.8	64.5	79.8	72.5	72.4	67.8	58.2	47.4	39.7	56.8
Highest temperature	88	98	99	105	111	109	107	111	105	99	97	85	111
Lowest temperature	10	16	20	26	40	46	60	57	44	24	22	17	10

(TABLE 1 continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Carrizo Springs, Texas 3-year record													
Aver. No. of days with .01 inch or more precipitation	2	3	3	3	5	3	3	2	4	3	3	2	36
Average temperature	53.5	59.4	64.5	71.8	78.5	83.9	86.4	86.9	81.4	72.5	61.6	53.5	71.2
Average maximum temp.	68.5	73.5	78.7	85.9	91.3	96.1	99.1	99.2	93.4	85.0	74.0	65.5	82.0
Average min. temp.	40.4	45.3	50.3	57.7	65.7	71.7	73.6	74.5	69.4	60.0	49.1	42.6	58.4
Highest temperature	87	98	99	101	106	111	108	108	104	191	89	84	111
Lowest temperature	13	23	21	36	44	59	62	61	50	54	26	20	13
Eagle Pass, Texas 28-year record													
Aver. No. of days with .01 inch or more precipitation	3	3	4	4	5	4	4	3	5	4	5	5	49
Average temperature	53.0	57.1	65.2	72.8	79.5	85.1	87.5	87.2	82.0	72.0	61.1	52.7	71.3
Average maximum temp.	66.8	71.6	80.5	86.1	92.3	97.7	99.8	100.2	94.5	84.9	74.2	65.9	84.5
Average min. temp.	39.0	43.2	50.3	59.6	66.8	76.4	75.2	74.8	69.8	58.5	48.4	40.0	58.5
Highest temperature	92	101	106	106	114	115	111	112	108	106	100	92	115
Lowest temperature	11	7	20	32	42	47	60	60	44	27	19	16	7
Fort Clark at Brackettville 30-year record													
Aver. No. of days with .01 inch or more precipitation	3	3	3	5	4	4	3	3	5	4	4	3	44
Average temperature	50.7	55.2	62.5	69.9	76.3	82.1	84.1	84.0	79.0	69.8	59.3	51.8	68.7
Average maximum temp.	63.1	67.8	74.5	80.3	86.8	95.1	95.3	95.5	90.0	80.8	70.2	62.6	80.0
Average min. temp.	39.5	42.5	50.3	57.1	64.4	70.5	72.1	72.5	68.6	58.6	48.2	40.1	57.1
Highest temperature	88	96	98	104	107	109	107	108	104	98	94	88	109
Lowest temperature	9	14	20	31	37	47	60	60	40	[illegible]	[illegible]	15	9

Records of wind movements are available only for 1951 at Winter Haven. The average monthly wind velocity in miles per hour is as follows:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
3.24	3.90	5.38	4.35	4.52	4.96	4.21	4.70	5.15

Oct.	Nov.	Dec.
4.56	5.35	3.52

To indicate performance of windmills Table 2 is included. However, due to the usual low wind velocities in this area it is advisable to increase the size of the mill by two feet over that shown in the table since these performances were compiled for conditions existing on the High Plains.

Geology

The rocks which outcrop within or in the vicinity of Elm Creek watershed range in age from Lower Cretaceous to Quaternary. In traversing the area from north to south, successively younger formations are crossed which are described subsequently in this order. All the formations have a normal dip to the southeast or east and their thicknesses increase from east to west.

The Edwards limestone crops out extensively in east central Kinney County along the northern boundary of the area and in west central Uvalde County near the northeastern side of the drainage area, and extends north to the Edwards Plateau.

TABLE 2

PERFORMANCE OF WINDMILLS PUMPING WATER AT VARIOUS LIFTS[1]
(IN GALLONS PER HOUR)

Wind Velocity Miles Per Hour	Diameter of Mill Fan Feet	50	100	150	200	250	300	350	400	450	500
5	8	26.2	13.1	18.7	6.5	5.2	4.3	3.7	3.3	2.9	2.6
5	12	59.4	29.7	19.8	14.9	11.9	9.9	8.5	7.4	6.6	5.9
5	16	107.0	53.5	35.6	26.7	21.4	17.8	15.3	13.4	11.9	10.7
10	8	209.0	104.5	69.5	52.2	41.7	34.8	29.8	26.1	23.2	20.9
10	12	475.0	237.0	159.0	119.0	95.0	79.0	68.0	59.0	53.0	48.0
10	16	855.0	427.0	285.0	214.0	171.0	143.0	122.0	107.0	95.0	85.0
15	8	705.0	353.0	235.0	177.0	141.0	118.0	101.0	88.0	79.0	71.0
15	12	1600.0	800.0	535.0	400.0	321.0	267.0	229.0	200.0	178.0	160.0
15	16	2890.0	1445.0	962.0	722.0	577.0	482.0	413.0	361.0	321.0	[illegible]
20	8	1670.0	835.0	557.0	417.0	334.0	279.0	239.0	209.0	186.0	[illegible]
20	12	3810.0	1905.0	1270.0	953.0	762.0	635.0	544.0	476.0	423.0	[illegible]
20	16	6840.0	3420.0	2280.0	1710.0	1370.0	1140.0	977.0	855.0	760.0	[illegible]

[1] Performance compiled for conditions existing on the High Plains.

The Edwards limestone consists of hard, dense, massive, more or less cavernous, marine limestone, and is the only limestone in the area which contains chert nodules. The cavernous characteristics of this formation make it the principal water-bearing formation in Uvalde and Kinney counties.

Water occurs in cracks, fissures, and channels in the Edwards limestone. In places, large interconnected caverns exist; when one of these large caverns is struck by the drill, water will rise several hundred feet in the well. Such a well can usually furnish several hundred gallons a minute with only a few inches drawdown. On the other hand, some caverns are small and not very well connected with other openings in the limestone; when the drill strikes such a cavern the water will only rise a few feet in the well and may have a drawdown of as high as 150 feet when pumping only 10 gallons a minute. Sayre states that, "A study of several wells that reach or penetrate the Edwards limestone seems to show that water occurs at three zones in the formation - one near the top, and one considerably below the top, and one near the bottom. In some wells all three zones contain water, in other wells, two or one of them, or perhaps none contain water."[1]

The Edwards limestone obtains part of its water from rains that fall on the outcrop area and then percolate down through fissures, fractures, and channels. It also obtains large quantities

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[1] Sayre, A. N., Geology and Ground-Water Resources of Uvalde and Medina Counties, Texas., U.S.G.S. Water Supply Paper 678, P.45, 1936

of water from streams and rivers which cross the outcrop area. Large quantities of water are lost annually from the Nueces, Dry Frio and Frio and other rivers into the Edwards as they cross the Balcones fault zone.

The Georgetown limestone, a hard, dense, resistant, argillaceous limestone, overlies the Edwards limestone in this area. It is not known to yield water in consequent quantities, and it is distinguished from the Edwards with difficulty.

The Del Rio clay which overlies the Georgetown limestone and is in turn overlain by the Buda limestone yields no water. This formation consists of a greenish-gray clay with some calcareous layers, and is readily identified as it is very fossiliferous, in parts.

Above the Del Rio clay lies a hard resistant, impure limestone with a resinous lustre known as the Buda limestone. It yields very small supplies of water to wells.

The Eagle Ford which consists of alternating calcareous to argillaceous flaggy limestones interbedded with black shale which weathers white, is not normally a water bearing formation in this area, but a few wells in Kinney County probably derive their water from this formation. (See Appendix I)

The Austin chalk overlies the Eagle Ford formation. It is a white to buff-colored chalk with some marly beds and in places contains considerable thicknesses of interbedded altered serpentine.

The Austin chalk yields small quantities of potable water to a few wells in the Elm Creek drainage area.

The Anacacho limestone lies between the Austin chalk and the Escondido formation. The Anacacho is a yellow to buff-colored sandy to clayey hard limestone. Excellent outcrops of this formation are to be seen in the Anacacho Mountains of Kinney County. This formation is in places impregnated with asphalt, especially in the vicinity of Blewett or Carbonville where it is mined as rock asphalt and is used as paving material. In years past this rock asphalt was shipped to the Atlantic seaboard, but this market has now collapsed due to a cheaper supply from other sources.

The Anacacho in the Elm Creek watershed, yields water only through fissures, faults, and fractures in the limestone. Wells which derive their water solely from this formation have only a small yield and the quality of the water is reported to vary from moderately mineralized to highly mineralized. As a whole, the Anacacho is a formation which cannot be expected to yield water in sufficient quantities or of satisfactory quality to feasibly justify an attempt to derive water from it. Since this formation yields water only in its fractured and fissured portions, many dry holes have been drilled in an attempt to find water in the Anacacho.

The Upson Clay which is mainly composed of gypsiferous clays, shales, sandy shales, and lime concretions with veins of barite and barite concretions, appears at the surface in northwestern Maverick

County and south-central Kinney County. The outcrop area decreases from west to east until it reaches the concealed fault east of Elm Creek where the Anacacho limestone is then exposed to the east.

The San Miguel formation consisting of clays, sandy shales, sands, and sandy limestone, crops out at the surface in a wide band in north-central Maverick, southeastern Kinney counties and in a narrow band in southwestern Uvalde and northwestern Zavala counties. The outcrop area diminishes rapidly east of Muela Creek to about a mile east of Gato Creek where it is no longer exposed at the surface. This formation yields only small supplies of water to a few wells in Maverick County.

The Olmos formation appears at the surface in a V-shaped band, from 0 to 6 miles wide in central Maverick County. Lignitic shales and sandy shales predominate in this formation. Iron concretions and silicified wood are common. This formation also has seams of coal and a few thin beds of sandstone. It is not known to be water bearing.

The Escondido formation is the highest Cretaceous formation in this area. It consists of hard, flaggy, calcareous to argillaceous, fine grained sandstone interbedded with shales. In places, the Escondido is impregnated with asphalt.

Sayre states, "Very few wells are known which undoubtedly obtain water from the Escondido formation. Large areas in which the Escondido forms the underlying rock are reported as being without

water. On the Smythe Ranch, west of the Nueces River, several wells have been drilled within a few miles of one another without obtaining any water in the Escondido."[1]

The Upson and San Miguel formations represent a change of phase in the Taylor formation of upper Cretaceous age and appear only in and to the west of this area in Texas. The Olmos formation also occurs only in this locality and together with the Escondido comprises the Navaro group at the top of the Cretaceous.

The oldest rocks of Eocene Age which appear at the surface in the Elm Creek drainage area belong to the Kincaid formation of the Midway group. The Kincaid formation is composed chiefly of glauconitic shales, lime concretions, impure limestone and thin sand sections. It is not known to yield water to wells.

Overlying the Midway group is the Indio formation of the Wilcox group. Micacecus, lignitic shales and sandy shales predominate in this formation. Seams of coal and beds of calcarecus sandstone, and limestone concretions are also present.

The Wilcox group yields water of fairly good quality to several livestock and domestic wells in southeastern and northeastern Maverick County and northern Zavala County; but, as a whole, moderately to highly mineralized water is to be expected from the sand sections of Wilcox.

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1 Sayre, A. N., Geology and Ground-water Resources of Uvalde and Medina counties, Texas, U.S.G.S. Water Supply Paper 678, P. 58.

The Carrizo sand unconformably overlies the Wilcox group. The Carrizo sand is composed of a clear usually crossbedded medium to coarse grained quartz sand with occasional lenses of shale. It is generally iron stained at the surface but in wells it is a clean quartz sand.

The Carrizo sand is by far the best water bearing formation in the watershed. The sand sections of this formation yield large supplies of water of excellent quality to irrigation, industrial, and municipal wells, as well as to stock and domestic wells.

The outcrop area of the Carrizo sand that supplies water to wells in Dimmit and Zavala counties covers about 175,000 acres.[1]

The water supply of the Carrizo sand is being continually replenished by rains that fall on, and streams that cross, the outcrop area. Storage tanks on the outcrop area are, at present, the only means of artificial recharge to the Carrizo; the amount of water they supply is negligible.

The Bigford member of the Mount Selman formation outcrops in the southeastern part of the Elm Creek watershed. The Bigford is composed chiefly of micaceous, gypsiferous shales and clays interbedded with sandstones and thin beds of limestone. The undifferentiated portion of the Mount Selman which overlies the Bigford crops out at the surface in a very small area in the southeast part of the watershed.

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1 White, Walter N., Summary Report on the Survey of the Underground Waters of Texas, March, 1935, P. 14.

Neither the [illegible] nor the undifferentiated portion of the Mount Selman are important water bearing formations in the area although some wells are known which yield fairly good supplies of Mount Selman water in Zavala County. Terrace deposits of silt, sand, clay, and gravel occur in large areas over the Elm Creek watershed.

The oldest of these gravel deposits is the Uvalde gravel believed to be of Pliocene Age. It is found capping hills and divides and consists of a coarse flint gravel and black silt. It is not known to be water bearing.

The Leona formation of Pleistocene Age consists of gravel and silt. It occurs as wide terraces in stream valleys and yields potable water to wells in the stream valleys south of the Edwards outcrop.

Recent deposits of gravel and silt occur in the lower stream valleys and yield small supplies of potable water to a few wells.

Table 3 summarizes the geological formations in the area with their respective water yielding characteristics.

Igneous rocks occur in the northern portion of the watershed in the form of what appear to be sills, stocks, and perhaps lacoliths.

The exact age of these igneous masses is not known but they are believed to be of Upper Cretaceous time. These igneous masses have very little, if any, effect on the underground waters of this area, except that where they are present ground water is not available.

TABLE 3.--SUMMARY OF GEOLOGICAL FORMATIONS IN THE ELM CREEK WITH THEIR RESPECTIVE WATER YIELDING CHARACTERISTICS

System	Series	Group	Formation	Thickness Feet	Water Supply
Quaternary	Recent			0'-50'±	Furnishes potable water in small quantities in [illegible] valleys
	Pleistocene		Leona	0'-100'±	Furnishes potable water in various quantities to [illegible] in stream valleys
Tertiary?	Pliocene?		Uvalde Gravel	0'-85'	Not known to be water bearing
Tertiary	Eocene	Claiborne Group	Mount Selman: Undifferentiated Mt. Selman		Insignificant in this area
			Mount Selman: Bigford Member	700'-800'	Yields small supplies of moderately to highly [illegible]ized water
			Carrizo Sand	150'-300'	Furnishes large quantities of good quality wat[illegible] eastern Maverick, Zavala, and Dimmit counties [illegible] used for irrigation purposes.
		Wilcox Group	Indio	350'-800'	In places yields adequate supplies of potable [illegible] stock and domestic use. Generally highly mi[illegible]
		Midway Group	Kincaid	125'-350'	Not known to be water bearing
Cretaceous	Gulf Series		Escondido	700'-120[illegible]±	Small yields of highly miner lized water
			Olmos	0'-500'±	Not known to be water bearing
			San Miguel	0'-400'±	In places yields small supplies of potable [illegible]
			Upson Clay	0'-500'±	In places yields small supplies of potable [illegible]
			Anacacho	200'-400'±	Yields adequate quantities for stock and domes[illegible] of moderately to highly mineralized water w[illegible] and fractures occur in the limestone
			Austin Chalk	200'-500'	Several wells derive water from this formation [illegible] Austin chalk has no definite potable water [illegible] therefore some wells are dry holes.
			Eagle Ford	50'-200'	Not definitely known to be water bearing, [illegible] wells may derive their supply from this format[illegible]
	Comanche Series	Washita Group	Buda Limestone	50'-125'	None
			Del Rio Clay	50'-125'	None
			Georgetown	50'-150'	Not known to be water bearing
		Fredericksburg Group	Edwards LS	500'-700'	Usually furnishes large quantities of goo[illegible]

The Balcones escarpment is the most prominent topographic feature in the area, and separates the Edwards Plateau from the Gulf Coastal Plain.

This escarpment is the result of a series of complex faults which are known as the Balcones faults. The Balcones fault zone extends from Austin nearly to San Antonio and there westward to about the confluence of the West Nueces and the Nueces Rivers. Near the confluence of these rivers the fault zone passes into a monoclinal fold, which continues westward.

The Edwards and kindred formations are brought to or near the surface in many places as a result of this faulting, and consequently the streams in northern Uvalde and northern Kinney counties are spring fed. All the streams in this area lose some or all of their water into the Edwards limestone when they cross the Balcones fault zone.

Some streams, such as the Nueces River, have thick gravel beds and much of their water passes into these gravels and gravel by-passes rendering the streams dry for long distances during the dry seasons until the surface elevation of the stream beds drop to such an extent that water again comes to the surface from these gravels in the form of springs.

Faulting which may or may not be part of the Balcones fault zone tends to impede the natural flow of the underground waters. Where these faults occur local accumulations of moderately to highly mineralized waters are to be expected.

The largest structural feature in the Gulf Plains portion of the Elm Creek watershed is the Chittim anticline. The anticline extends across Maverick County from northwest to southeast; from about the Paloma switch on the G.H. and S.A.R.R. in an almost straight line to the east line of Maverick County where it bends eastward and passes south of Carrizo Springs in Dimmit County. As the formations are normally dipping gently to the south or southeast, water is encountered under artesian conditions southeast and south of the outcrop area.

Soils

The soils of the northern hilly portion of the area belong mainly to the Valera Group.[1] This series is characterized by brown or dark brown surface soils and brown or yellow subsoils. The soils are mostly shallow and calcareous since they rest mainly on limestone. The stony clay type is the principal one present but some areas of the more productive clay and clay loam types also occur on the smoother locations. Most of the ranching in the northern part of the area is conducted on the stony clay type soils.

The central and southern portions of the area are occupied by soils of the Maverick--Zapata and the Webb--Duval series. The Maverick--Zapata group occurs on much of the land along the western border of the area while the Webb--Duval soils are present in the south-central part of the area in southern Zavala and northern

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1 Carter, W.T., "The Soils of Texas," Texas Agric. Exper. Sta., Div. of Soil Survey, Bull. 431, July 1931, pp. 119.

Dimmit counties.

The Maverick--Zapata group have brown, gray or grayish-brown surface soils with gray to light brown or yellow subsoils. Both soil and subsoil are calcareous and most of the soils are sandy and loamy.

The Webb--Duval series consists mainly of reddish-brown soils. Coarse, intermediate and fine textured soils are represented, including sandy loams, clayey loams, and silty clay loams. The parent materials of these soils are of the Claiborne geologic group and the Uvalde terrace gravels.

The coarse textured soils are most adaptable to both dry land and irrigated farming and make up a major part of the area cultivated at the present time. Ranching and subsistence farming are largely common to the areas of fine textured soils.

Surface Water Discharge

There are no gaging stations located within the Elm Creek watershed and no discharge records of any description are available for streams within the area. For purposes of run-off analyses, discharge records of the Nueces River at the Laguna, Uvalde, and Cotulla stations and of the Frio River at Con Can (Tables 4 to 7 inclusive) are included in this report. Both of these streams are east of, but in the general vicinity of, the area and may be expected to exhibit discharge characteristics somewhat analogous to those of Elm Creek drainage. However, the Nueces River is a major stream in

this locality and both it and the Frio River have a considerable part of their upper drainage areas located in the Edwards Plateau. These factors may preclude a direct analogy between discharges of these streams and that of the Elm Creek drainage, although many of the physical features are comparable.

The average annual run-off on the Nueces River per square mile of drainage area is about 130 acre-feet at Laguna, 80 acre-feet at Uvalde, and 50 acre-feet at Cotulla, and for the Frio River at Con Can is about 210 acre-feet as based on a 12-year record up to and including 1936.

The peak discharge recorded on June 14, 1935, reached a high of about 295 and 320 cubic feet per second per square mile of drainage area at Laguna and Uvalde, respectively. However, the discharge of this flood at Cotulla about 75 miles below Uvalde amounted only to approximately 15 cubic feet per second per square mile of drainage area. This phenomenon may be accounted for by the fact that practically all of the precipitation which produced this flood fell on the upper reaches of the watershed north of Uvalde. The peak flow recorded for the Frio River at Con Can amounted to about 335 cubic feet per second per square mile.

The excessive discharge may be attributed in part to the fact that rains of high intensities occur north of the Balcones fault zone near the heads of the Nueces and Frio River drainages, and to the fact that land slope gradients are rather high and land slopes are generally rocky and conducive to rapid run-off.

The discharge records as well as the precipitation records for this area show extreme fluctuations. Because of this characteristic records of mean annual discharges are relatively unimportant in estimating water supplies.

Similar physical conditions exist in the Elm Creek watershed except that its streams head south of the Edwards Plateau where rainfall intensities are somewhat lower and the rocky land slope area is restricted to a smaller part of the drainage area. Consequently unit run-off in the Elm Creek watershed is probably lower than that of the Nueces and Frio Rivers, although there are no records to confirm this conclusion.

Flood Damage

No monetary estimate has been made nor can be made of flood damage within the Elm Creek area, but the Corps of Army Engineers has estimated the damage produced by the 1935 flood on the Nueces River to aggregate $10,000,000.00. This loss was confined chiefly to railway and highway facilities. The region is sparsely populated and no towns are located on the Nueces River in this locality, and none were affected by the flood.

TABLE 4.—ANNUAL PEAK FLOODS IN CUBIC FEET PER SECOND AS RECORDED AT STATIONS ON THE NUECES AND FRIO RIVERS IN TEXAS

	The Nueces River			The Frio River
Year	at Laguna	at Uvalde	at Cotulla	at Con Can
	764	1,930	5,260	485
1924	2,220		4,610	1,200
1925	15,600		49,500	
1926	27,000		9,820	30,400
1927			1,440	800
1928	7,440	1,320	11,400	
1929	21,200	14,500	22,100	2,000
1930	47,500	57,500	6,940	Not determined
1931	30,800	27,000	2,920	Not determined
1932	41,800	188,000	40,500	162,000
1933	572	643	4,520	584
1934	213,000	616,000	82,600	86,900
1935	114,000	55,000	14,500	103,000

TABLE 5.—COMPOSITE DISCHARGE RECORD OF THE NUECES RIVER AT THE LAGUNA GAGING STATION FOR A 13-YEAR PERIOD, DURING 1923 - 1936[1]

	Average Maximum Cu. Ft. per Second	Average Minimum Cu. Ft. per Second	Average Mean Cu. Ft. per Second	Average Run-off Acre-feet
October	1,591	67	191	9,800
November	260	81	116	6,875
December	106	67	70	4,860
January	94	65	68	4,260
February	125	67	84	4,700
March	80	67	67	4,650
April	221	53	70	4,700
May	1,831	57	238	12,510
June	10,700	94	606	27,460
July	2,930	74	210	11,124
August	624	54	98	4,410
September	4,500	75	400	23,730
Average Monthly				9,923

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1 No record included for 1934

Location — one mile northeast of Laguna, Uvalde County.

Drainage area — 764 square miles.

Average discharge 12 years— 165 cubic feet per second.

Maximum discharge June 14, (Slope Area method) — 215,000 cu.ft. per sec.

Revised discharge — 226,000 cu. ft. per second 1913 and September 1923.

Slightly higher stage 1903.

TABLE 6.—COMPOSITE DISCHARGE RECORD OF THE NUECES RIVER AT THE UVALDE GAGING STATION FOR A 7-YEAR PERIOD, DURING 1928 - 1936.[1]

Uvalde

	Average Maximum Cu. Ft. per Second	Average Minimum Cu. Ft. per Second	Average Mean Cu. Ft. per Second	Average Run-off Acre-feet
October	1,367	90	160	9,835
November	50	37	45	2,258
December	53	25	25	3,800
January	65	23	19	1,177
February	35	13	22	1,218
March	53	8	16	1,028
April	127	8	15	875
May	2,448	25	241	14,838
June	5,367	60	1,411	83,344
July	1,427	48	70	7,530
August	164	22	44	2,716
September	11,512	74	781	55,124
Average Annual				15,145

Drainage area — 1,930 square miles.

Extreme discharge June 14, 1935 (Slope Area method) — 616,000 cu. ft. per second.

[1] No record included for 1934

TABLE 7.--ANNUAL RUN-OFF OF DRAINAGE AREA OF THE NUECES RIVER AT COTULLA, TEXAS AND OF THE FRIO RIVER AT CON CAN, TEXAS, 1924 - 1936.

Annual Run-off in Acre-feet

	Nueces River Cotulla, Texas[1]	Frio River[2] Con Can, Texas
1924-	147,000	82,600
1925-	345,000	24,200
1926-	139,000	65,500
1927-	50,900	53,100
1928-	171,000	23,500
1929-	279,000	23,400
1930-	160,000	No Record Published
1931-	152,000	149,000
1932-	279,000	23,400
1933-	107,000	80,300
1934-	N O R E C O R D	I N O F F I C E
1935-	1,035,000	221,500
1936-	381,400	126,600
Average	270,525	79,370

1 Cotulla Station located in Cotulla, La Salle County, Texas. Drainage area is 5,260 square miles. A large part is non-contributing because of water entering fault near Uvalde. Records available October 1923, to September 1936. Average discharge for 13 years is 385 cu. ft. per second. Extreme discharge of 62,600 cu. ft. per second occurred June 18, 1935. Most low water flow is diverted by pumping above station.

2 Con Can Station located one-half mile below Con Can Post Office, Uvalde County, Texas. Drainage area is 485 square miles. Records available October 1923 to September 1936. Average discharge for 11 years is 130 cu. ft. per second. Extreme discharge of 162,000 cu. ft. per second occurred July 1, 1932. There is no diversion of water above gaging station.

III

PRESENT USE OF AREA

Ground Water Use

In an attmept to define existing ground water resources, the area has been subdivided into three subareas, each of which present certain characteristics of more or less uniformity which determine the possibility of ground-water recovery.

Subarea 1 is delineated as that part of the watershed which lies north of the east-west line which roughly parrellels the highway between Uvalde and Brackettville.

In this subarea, the Edwards limestone is from 200 to 1,000 feet below the surface. The depths to which the Edwards limestone is encountered in wells depends largely upon the surface elevation of the well and the distance the well is from the outcrop area. All things being equal, the depths to the Edwards are progressively greater from north to south in this subarea.

Water from the Edwards limestone although relatively hard is of a good enough quality to be used for most purposes. Some wells yield water from the Edwards limestone which is rather heavily charged with hydrogen sulfide. The obnoxious odor of this gas can be easily eliminated by aeration.

In this subarea the Austin chalk also yields potable water to a few wells. As the Austin chalk does not have any water horizons which are everywhere continuous, it is believed that the water

enters these wells through fissures and fractures.

Subarea 2 is delineated as that portion of the watershed which lies north and west of the Wilcox—Carrizo contact and south of the south line of subarea 1.

In this subarea the Carrizo sand is not present. The Edwards limestone in most of the area is too far below the surface to make it feasible to drill wells into the Edwards in search of water.

A few wells in subarea 1 obtain water of questionable quality and in small quantities from the Austin chalk, Anacacho limestone, San Miguel, Escondido, and Wilcox formations. However, none of these formations as a rule furnish water in adequate quantities or of suitable quality to justify the drilling of wells in this area. Where gravel terrace deposits exist along the stream beds in this subarea potable water in adequate supplies for stock and domestic use is generally encountered at shallow depths.

Subarea 3 is that portion of the Elm Creek watershed which lies south and east of the Wilcox—Carrizo contact.

In this subarea the Carrizo sand is the principal aquifer. The Carrizo sand is reached at progressively greater depths from north to south and from west to east. The Carrizo sand is at the surface in a band six to eight miles wide which roughly parallels the northern and western boundary of this subarea.

Water in the Carrizo sand may now be in a state of hydraulic balance.

The two principal aquifers in this area, the Edwards limestone, which supplies most of the water to subarea 1, and the Carrizo sand, which supplies most of the water to subarea 3, will be discussed in detail.

Edwards Limestone.—The Water in the Edwards limestone is under artesian pressure. The hydrostatic pressure appears to fluctuate with the rainfall. During dry seasons the static water levels will gradually drop whereas following heavy rains the water levels rise.

The artificial withdrawal of water from the Edwards limestone has not been sufficiently great to materially affect the natural hydraulic balance. The largest artificial withdrawal from the Edwards is for municipal and industrial supplies. A few tracts of land, in northern Uvalde County, are irrigated by Edwards water. The remainder is withdrawn for stock and domestic use.

The Edwards limestone loses large quantities of water through fault springs and other natural methods. The Las Moras spring at Brackettville has an average discharge of 34 cubic feet per second. There are numerous other springs in, and in the vicinity of, the Elm Creek watershed which are fed by waters from the Edwards limestone. The water in the Edwards limestone, being under artesian conditions, moves upward along fault planes and discharges in many places at the surface in the Nueces and Frio Rivers. Some Edwards water is also lost by transpiration and evaporation.

<u>Carrizo Sand</u>.--The Carrizo sand which outcrops extensively in the watershed furnishes most of the water used for irrigation in the "Winter Garden Area."

The United States Geological Survey in cooperation with the Texas Board of Water Engineers has made an extensive investigation of the ground-water supplies of Dimmit and Zavala counties, and consequently much of their published and unpublished information has been used in this report.

The Carrizo sand is being continually replenished by rains that fall on, and streams that cross, the outcrop area.

Since the Carrizo sand is dipping under the surface at an angle greater than the land slopes, the water in the Carrizo sand is under artesian pressure. When wells were first drilled into this formation the artesian pressure was great enough to cause most of the wells to flow.

Irrigation on a large scale was first started in about 1911, and this practice continued to increase until it reached a peak in 1929 and 1930. Since 1930, farming in this area has been decreasing and numerous farms have been abandoned.

When the development of the Carrizo artesian reservoir was begun, drillers noted that the sand sections of formations above the Carrizo sand were dry. In many cases in the "Winter Garden Area" only surface casing was installed in the wells, as the formations above the Carrizo sand did not cave readily. Therefore, water from

the Carrizo sand entered the sand sections of the formations overlying the Carrizo, filling them with water.

The sand sections of the formations above the Carrizo sand are micaceous, gypsiferous, and rather highly charged with various soluble salts. Therefore, the water which entered these sand sections dissolved much of the salt and is now highly mineralized. This highly mineralized water is now contaminating numerous wells. The resultant contamination, in many cases, precludes further use of the wells for any purpose.

The hydrostatic head of the Carrizo sand has dropped to such an extent that where wells once flowed at the surface the static water levels are now from 50 to 150 feet below the surface. According to the best information available the lowering of static head in the Carrizo sand has now stopped, and a rise of 0.10 of a foot was noted when the static water levels were last measured. The drop of the water table within the Carrizo sands had been due, mainly, to the large withdrawals of water from the reservoir and, in part, to the fact that some of the head is lost when water moves laterally into the sand sections of the overlying formations. The 0.10 of a foot rise in static level, although comparatively small, is significant because it shows that the natural hydraulic balance in the Carrizo reservoir has been reached.

A tentative estimate[1] (based on the average thickness, average coefficient of permeability, and average hydraulic gradient

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1 White, Walter N. Summary report on the survey of the underground waters of Texas; p.14. March 1935.

of the Carrizo sand) is that 27,000 acre-feet of water a year moves by percolation from the outcrop area to the pumped districts. The United States Geological Survey reports that approximately 25,000 acre-feet of water were withdrawn from the reservoir in 1929 and 1930, and that materially less water has been withdrawn annually since then.

Ground-Water Control

The only legal ground-water control in Texas is vested in the Texas Board of Water Engineers as provided in the following articles:

REVISED CIVIL STATUTES
TAKEN FROM
VERNON'S TEXAS STATUTES - 1936

Art. 7600: Artesian well defined. An artesian well is defined for the purposes of this chapter to be an artificial well in which, if properly cased, the waters will rise by natural pressure above the first impervious stratum below the surface of the ground. (Id. sec.90.)

Art. 7601: When artesian well declared a public nuisance. Any artesian well which is not tightly cased, capped and furnished with such mechanical appliances as will readily and effectively arrest and prevent the flow from such well, either over the surface of the ground about the well, or wasting from the well through the strata through which it passes, is hereby declared a public nuisance and subject to be abated as such, upon the order of the Texas Board of Water Engineers. (Id. sec.91.)

Art. 7602: Waste defined. Waste is defined for the purposes of this act, in relation to artesian wells to be the causing, suffering, or permitting the waters of an artesian well to run into any river, creek, or other natural watercourse or drain, superficial underground channel, bayou, or any sewer, or street, road, highway, or upon the land of any other person than that of the owner of such well, or upon the public lands or to run or percolate through the strata above that in which the water is found, unless it be used for the purposes and in the manner in which it may be lawfully used on the premises of the owner of such well. (Id. p. 233, sec.92)

Art. 7603: Proper irrigation of trees, etc. Nothing in the preceding article shall be construed to prevent the use of such water, if suitable for proper irrigation of trees standing along or upon any street, road, or highway, or for ornamental ponds or fountains, or the propagation of fish, or for the purposes authorized in this chapter. (Id. p. 233, sec.92).

Art. 7604: Well properly cased. Whenever any person desires to drill a well upon his own land for domestic purposes or for use for stock raising purposes or use that comes within the definition of artesian well, as defined in this chapter, he shall have the right to do so without subjecting himself to the provisions of this chapter, provided that such well shall be properly and securely cased, and whenever water is reached containing mineral or other substances injurious to vegetation or agriculture, it shall be the duty of the owner of said well to securely cap same or to control its flow so as not to injure the land of any other person, or to fill it up so as to prevent the water of said well to rise above the first impervious stratum below the surface of the ground. (Id. sec.93).

Art. 7605: Accurate record kept. Any person boring or causing to be bored any artesian well shall keep a complete and accurate record of the depth and thickness and character of the different strata penetrated, and when such well is completed shall transmit by registered mail to the Board of Water Engineers the copy of such record. (Id. sec.94).

Art. 7613: Penalty for permitting waste. Whoever wilfully causes or knowingly permits waste as defined in this chapter, shall be fined in any sum not exceeding $500.00, or shall be imprisoned in jail not more than 90 days, or by both such fine and imprisonment. (Acts 1917 p. 234, sec.101).

Art. 7614: Sworn statement. Any person, association of persons, corporation, or water improvement or irrigation district, owning or operating any artesian well, as defined for the purposes of this chapter, at the time of its taking effect, shall, within one year thereafter, transmit to the Board of Water Engineers a sworn statement showing results of such test, together with the declaration of the use or uses to which the newly developed supply will be devoted, and the contemplated extent of such use. (Id. p. 235, sec.102)

Art. 7615: Detailed statement furnished. On or before the first day of March of each year, every person, association of persons, corporation, water improvement or irrigation district who, during any part of the preceding claendar year, owned or operated any artesian well for any purpose other than that of domestic use, shall furnish under oath, to the Board of Water Engineers, upon blanks to be furnished by the Board, a detailed statement showing quantity of water which has been derived from such well and the character of such use to

which the same has been applied, together with the change in level of water table of said well, and if used in irrigation, the acreage and yield of each crop, together with such additional data as the Board of Water Engineers may require. (Id. sec.103.)

This law has proved ineffective, and, as there are no quasi-public or public agencies for control of ground water in this section of Texas, flagrant waste, misuse, and improper casing practices are common.

Operation of Wells

In Dimmit and Zavala counties, about 15 per cent of the irrigation wells are permanently abandoned, 30 per cent temporarily abandoned, 30 per cent are still being used but are in need of repair, and only 25 per cent of the wells are in good condition.

Surface Water

At present surface water is not being utilized for irrigation purposes within the area. Irrigation is confined chiefly to that portion of the area in which ground water is available from the Carrizo sand.

Existing Water Facilities

The records of most of the existing wells in this area are shown in Appendix 1. The location of the existing tanks and wells are shown on Plate 2.

In subarea 1 wells and tanks are inadequate to supply the present needs. Cattle are often required to travel too far for water. In subarea 2, where wells are difficult to obtain, tanks are the only means of obtaining water supplies for livestock. These tanks and the few wells that do exist are also inadequate to supply the present needs.

There are no municipalities in the area. However, the water facilities of the towns adjacent to the area are as follows:

Brackettville and Ft. Clark obtain their supplies from Las Moras Spring. This spring has an average discharge of 34 cubic feet per second.

Eagle Pass uses water from the Rio Grande. The quantity is unknown.

Carrizo Springs and Crystal City both have wells which are drilled into the Carrizo Sand. Both communities use from eight to ten million gallons a month.

Uvalde gets its water from wells drilled into the Edwards limestone. At Uvalde there are five drilled wells, eight inches in diameter, in the bottom of a sump. (Four shallow wells less than 100 feet deep and one well 350 feet deep.) It is thought that most of the water comes from the deepest well. These wells are capable of pumping 1,500 GPM continuously with a draw-down of only eight inches.

The City of Uvalde has recently completed a new well 15 inches in diameter and 478 feet deep. This well, on test showed

a draw-down of 63 feet after pumping 1,000 gallons a minute for 36 hours. The city of Uvalde pumped the following quantities of water during 1937.

Month	Gallons	Month	Gallons
January	8,148,750	July	22,125,000
February	8,676,750	August	27,474,750
March	9,825,750	September	19,960,500
April	15,222,750	October	16,494,750
May	19,983,000	November	10,089,750
June	18,384,750	December	10,254,750

CHEMICAL ANALYSES OF UVALDE CITY WELLS IN PARTS PER MILLION.
NEW WELL - SAMPLE TAKEN APRIL 1, 1939

Total solids - 340	Calcium 61	Carbonates 0.0
pH - 7.3	Magnesium 8.1	Bicarbonates 260
Total alkalinity 0.0	Sodium 186	Sulfates 15
Silica Residue 32.	Fe (Total) 1.25	Chlorides 14
Color 40.	Mn less than 0.01	Fluorides 0.4
Turbidity 50	Fe (Dissolved) 1.2	Nitrates 9.0

IN PARTS PER MILLION
OLD WELL H-5-1 OF W.S.P. 678

Total solids 260	Calcium 84	Carbonates 0.0
pH - 7.3	Magnesium 11	Bicarbonates 268
Total alkalinity 220	Sodium (Calc) 6	Sulfates 11
Silica residue 10	Iron .05	Chlorides 14
Total hardness 255	Manganese less than .02	Fluorides 0.2
Color 10		Nitrates 9.0

Sample taken October 31, 1938

Both analyses by Texas State Department of Health, Austin, Texas

Land Use and Type of Farming

There are approximately 897,920 acres in the area and only 1.27 per cent under cultivation. Due to the erratic rainfall and occasional long droughts the carrying capacity of native pasture is rather low. The normal carrying capacity is 15 acres per animal unit, but overgrazing during recent years has depleted the vegetative cover until about 25 acres are now required for each animal unit. This area is generally known as a steer grazing section, but many sheep have been introduced in recent years in some of the ranches. Where sheep have been introduced, overgrazing is quite pronounced. Probably from 40 to 50 per cent of the range sustenance is obtained from trees, browse plants, and shrubs.

It is estimated that 11,460 acres are cultivated and of this amount 11,000 acres are irrigated and comprise part of the "Winter Garden" district in Dimmit and Zavala counties.

The main crops consist of vegetables, but grain sorghums, corn, sudan, peanuts, and flax are produced in small quantities. Onions and spinach have been the main vegetables, but at the present time the acreage devoted to these vegetables seems to be decreasing.

The soil in the irrigated sections has been damaged to some extent by well irrigation from salt contaminated wells. In many instances the damage was not known until the crops were killed. Diseases seem to be on the increase on practically all of the vegetables especially spinach which has been affected seriously by the curly

top disease. This disease has reduced the yield of spinach to such an extent that the crop is rapidly becoming unprofitable to grow. The effect of the contaminated wells on the soil will be more definitely determined when the comprehensive study of the irrigated portion of the watershed is completed.

In the irrigated districts cash crops consisting primarily of vegetables are produced every month in the year. Relatively few farm operators in the irrigated sections carry on general farming. Those who do, generally raise feed crops by dry land farming, have considerable pasture land for grazing and only irrigate a small acreage of vegetables.

Nearly all of the 460 acres estimated to be cultivated in parts of Uvalde, Kinney, and Maverick counties included in Elm Creek watershed are used to produce feed crops to supplement the grazing during the winter months.

Ranching is the predominant enterprise in the area and steer grazing is the main activity. Very few steers are produced in the local area, but are shipped in as yearlings and carried on the pastures until they are two, three, and four years old. If grass is good and the price low they may be carried until five years old. One company operates nearly half of the area or 375,000 acres.

It has been common practice in the area during drought years to supplement the native forage by burning the spines off the cactus (pear) in order that stock may eat it without injurious effects.

[illegible]
supplemented by other feed such as meal or cotton seed cake, [illegible] will carry stock through the season. The wisdom of this practice is questionable.

Since apiaries are numerous within and in the vicinity of the area, there is considerable objection to the clearing of brush which serves as a source of nectar for the bees. Since the forage of the area consists largely of browse plant which usually have a lower palatability than grasses, the carrying capacity of the range is comparatively low. The browse forage is well adapted to sheep and goat raising.

Ownership and Residence of Operators

Land ownership and residence of operators within the watershed, with the exception of those in Dimmit County, are given in the following table:

OWNERSHIP AND RESIDENCE OF OPERATORS

County	No. Farmers	No. Resident Owners	No. Non-Resident Owners	Per cent Resident	Per cent Non-Resident
Maverick	16	9	7	56	44
Kinney	27	16	11	59	41
Zavala	50	41	9	82	18
Uvalde	15	10	5	66	34

Land Values

The grazing lands are valued from $3.50 to $6.00 per acre. The irrigated sections which are still in operation range in value from $100.00 to $125.00 per acre. The area which has been damaged by salt water is not worth much more than grazing land under its present condition, but most of the land probably is not damaged sufficiently to prevent its being reclaimed. The soils are generally coarse textured and the drainage is good which will facilitate reclamation.

Population and Public Facilities

There has been a slight decrease in population since 1930. Areas formerly under irrigation but now abandoned have probably lost a part of their population. However, the Texas Almanace, 1939, indicates a slight increase in population.

Schools are located in the towns and villages in and adjacent to the area. There are no small one-teacher schools. Some of the pupils have to go by bus 35 or 40 miles to school. On all-weather roads, the trip does not take long.

Roads are generally adequate around the area, but the ranching areas do not have any system of lateral roads.

The ranches usually have their own domestic light plants, and in the irrigated sections electricity is used to pump water.

The Uvalde-Del Rio highway is the only hard surfaced road crossing the area. The La Pryor-Eagle Pass and the old Uvalde-Eagle Pass roads are improved roads and the only ones crossing the central part of the area. The Carrizo Springs-Eagle Pass road crosses the extreme southern tip of the area.

In general roads and public utilities are scarce within the watershed.

IV

RECOMMENDED FUTURE AREA UTILIZATION

At the present time the irrigated portion of the Elm Creek watershed appears to be one of major maladjustment in practically all phases of land utilization. Remedial measures for agricultural adjustment are imperative but before an adequate plan for adjustment can be proposed, an exhaustive study of both the local and regional economics of this section of the watershed is necessary.

Over 98 per cent of the watershed is utilized for stock raising. Large areas of native pasture are now practically barren. Agricultural Conservation Program range supervisors report the normal capacity of the range land to average about 15 acres per animal unit. Present practice provides deferred grazing on about 8 to 10 acres per animal unit. This has reduced the actual carrying capacity to 20 to 25 acres per animal unit in order to allow for pasture recovery. Overgrazing is particularly apparent in the vicinity of watering places since stock water facilities are generally at a minimum. A better distribution of tanks and wells should be provided in order that stock need not walk over 1½ miles to water or one facility to every 4 sections or approximately 2,500 acres. Barriers, the limited supplies of wells, and locations for tanks which can catch sufficient water for approximately 100 head of cattle may, in some instances, make it necessary to

install more than one stock watering facility per 2,500 acres. However, these instances should be the exception.

The wholesale clearing of cacti and brush on the range land is not to be recommended as the cost is prohibitive on land of this value. However, where dense growths of obnoxious plants and shrubs occur, these dense growths should be thinned.

Since the browse forage is well adapted to the raising of sheep and goats, this industry appears suitable within the area and would serve to decrease the density of brush which is objectionable on a cattle range.

Flood irrigation is physically possible in many places within the grazing portion of the area. By the use of spreader terraces to divert and retain flood waters the carrying capacity of the area can be increased materially. The erratic nature of the water supply and returns compatible with expenditures should be given careful consideration. The cost of spreader terraces should average about $2.00 per 100 linear feet as based upon experience in adjacent areas.

In an attempt to provide specific recommendations on the use of water the watershed has been divided into subareas, Plate 2, in which certain suggestions and recommendations are applicable.

In subarea 1, it is recommended that stock and domestic water supplies be obtained by drilling wells into the Edwards limestone. Where adequate supplies of potable water are encountered

in the formations which overlie the Edwards limestone, these supplies should be utilized. As the initial cost of a well is higher than that of a storage tank, the latter might well be used to supplement the drilling of wells.

In subarea 2, there are only a few places where potable ground water in adequate quantities for stock and domestic use can be obtained. Therefore, in this subarea, tanks should be built to obtain stock water and cisterns for water supplies to be used for domestic purposes.

In subarea 3, the Carrizo sand is capable of furnishing adequate quantities of excellent water for stock and domestic needs, and additional wells for these purposes can be drilled without materially affecting the existing ground-water supply.[1] Additional ground-water irrigation is not to be encouraged, nor should new wells be drilled into the Carrizo sand for irrigation purposes. Many irrigation wells in this subarea are polluted with salt water from the sand sections of the Bigford formation, due to the fact that only surface casing or cheap second hand casing was used when the wells were first drilled. Salt water contamination has continued unabated until, at present, it is probably the major problem of the entire "Winter Garden" area of Zavala and Dimmit counties. The correction and control of this salt water problem will be determined when the comprehensive study of this portion of the watershed is completed. This study

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1 Irrigation of small gardens when it can be accomplished from domestic and livestock wells is recommended.

must be made before any definite recommendations or conclusions can be drawn regarding the economic feasibility of repairing contaminated irrigation wells.

APPENDIX I

Well Records

RECORDS OF WELLS IN KINNEY COUNTY[1]

Well No.[2]	Distance from	Owner	Date Drilled	Depth (Feet)	Size of Casing in in.	Chief Aequifer	Depth to Water (Feet)	Date	Use of Water	Remarks
7		N.P. Peterson	old	475	6	Edwards?	178	----	D. S.	6" csg to 20[illegible]
9		do	1934	350	6	do?	183	----	S.	----
10	Brackettville 12 miles E.	do	1883	266	8	do	203.1	12/16/37	S.	----
12		B. B. Dunbar	1938	350						Well drilled [illegible] Basott no [illegible]
13		do	1938	351	--	Edwards	207	----	S.	Prob. starts [illegible] Georgetown [illegible]
14	Brackettville 12½ E	do	old	----	8	do	200	12/16/37	S.	----
17	do	R.H. Earwood	do	300	6	Austin(?)	64.8	11/23/37	S.	Weak supply
19	do 13½ E.	George Rose	1925	432	5 3/16	----	325(?)	----	S.	----
21	do 16½ E.	Ralph Harris	old	300	6½	----	58.5	----	S.	----
22	do 14½ E.	R.F. Earwood	do	320	6	----	76.7	11/24/37	--	Strong supply
22-A	do 13 E.	George Rose	1908	260	8	----	125.6	do	D. S.	do
22-B	do do	do	old	60	36	Dry well	----	----	--	do

[1] Unpublished U. S. Geol. Survey Data

[2] Well numbers correspond to [illegible]

RECORDS OF WELLS IN KINNEY COUNTY (continued)

Well No.	Distance from	Owner	Date Drilled	Depth (Feet)	Size of Casing in in.	Chief Aquifer	Depth to Water (Feet)	Depth to Water Date	Use of Water	Remarks
22-C	do 15½ E. 4	Dave Rose, Jr.	1925	285	5 3/16	Edwards	146.1	11/24/37	D. S.	----
23	.7W of Co. Line	Buddy Harris	old	150	6¼	Austin	62.64	11/19/37	S.	----
24	do	J. Hunter	do	180	4½	do	68.4	11/10/37	D. S.	----
25	.3W do	Ethel Whitaker	1928	104	9½	do	58.7	8/18/37	D. S.	----
26	Brackettville 15½ E.	G. C. Earwood	1936	112	4½	----	----	----	---	----
27	9½ S.E. do	do	do	----	8	Austin	147.8	4/4/38	S.	----
28	12½ E. do	do	do	250	6	do	60.7	8/20/37	D. S.	----
29	9½ S. E. do	Mrs. G.A. Harrison	1934	271	8	Eagleford(?)	81.5	----	S.	----
30	7½ E. do	H. J. Toft	1920	312	6¼	Edwards(?)	109.1	4/4/38	S.	----
31	----	Mrs. G.A. Harrison	1938	514	6 5/8	do	71	----	S.	----
32	----	Mrs. G.A. Harrison	1938	269	6 5/8	Eagleford(?)	161	----	S.	----
34	Brackettville 13½ E.	R. H. Earwood	1927	250	6	Austin	98.7	8/18/37	D. S.	2½" tubing [illegible] surface [illegible]
35	12½ E. do	do	1922	1000	8	Edwards	94.6	11/24/37	S.	Base of [illegible] to [illegible]
36	13½ E. do	do	old	[illegible]	[illegible]	----	47.3	do	--	[illegible]
37	11 E. do	Pat Rose	1934	[illegible]	[illegible]	----	----	----	[illegible]	[illegible]

RECORDS OF WELLS IN KINNEY COUNTY (continued)

Well No.	Distance from		Owner	Date Drilled	Depth (Feet)	Size of Casing in in.	Chief Acquifer	Depth to Water (Feet)	Depth to Water Date	Use of Water	Remarks
38	10 E.	do	Mrs. G.A.Harrison	old	200	8	----	58.5	---	S.	----
39	11 E.	do	do	1936	250	8	----	211.(?)	---	S.	----
40	9 E.	do	do	old	120	5 3/16	----	106.7	---	S.	----
41	----		Fritter	---	200	6	Edwards	124	---	S.	----
42	----		do	1912	500	6	do	115	---	D. S.	Yields [illegible]
43	----		do	old	500	6	do	50	---	S.	Del Rio [illegible]
56	4.15 Brackettville		Ed. L. Hobbs	do	180	6	----	49.2	4/2/38	D. S.	----
57	do		H. J. Toft	1918	133	$6\frac{1}{4}$	----	9.6	4/4/38	D. S.	----
58	6 S.E.	do	Judge John Fritter	---	----	6 -$2\frac{1}{2}$	Austin	27.89	8/19/37	S.	----
59	12.8 W.	do	H. S. Toft	1912	112	6	do	30.2	11/10/37	D. S.	----
60	7 S.E.	do	do	1936	100	$8\frac{1}{4}$	do	10.5	4/4/38	S.	Water in [illegible] and fissures [illegible]
62	9 S. E.	do	do	1928	150	$6\frac{1}{4}$	----	52.5	do	S.	Permanent [illegible]
63	----		R. W. Morrison	---	100	6	Anacacho	19	---	D. S.	----
64	----		do	---		6	do	18	---	D. S.	----
65	----		L. L. Pharr	1937	[illegible]	---	----	---	---	---	No [illegible]
66	----		do	do	[illegible]	---	----	---	---	---	do

RECORDS OF WELLS IN KINNEY COUNTY (continued)

Well No.	Distance from	Owner	Date Drilled	Depth (Feet)	Size of Casing in in.	Chief Aquifer	Depth to Water (Feet)	Depth to Water Date	Use of Water	[illegible]
67	Brackettville 15½ S. E.	O. R. Altizer	1934	207	8¼	----	115	--	S.	100' of [illegible] pipe [illegible] [illegible]
67-A	17 S. E. do	J. L. Pingenot	1925	104	4½	Anacacho	43.9	11/23/37	--	----
67-B	17½ S. E. do	do	1900	350	6	----	36.8	do	S.	----
67-C	Brackettville 18 S.E.	J. L. Pingenot	1925	200	4½	Anacacho	115.8	11/23/37	S.	
67-D	17½ S. E. do	do	do	100	6	do (?)	40.2	do	S.	
68	16 S. E. do	O. R. Altizer	1931	400	6	----	40	--	S.	----
69	do do	do	1930	100	6	----	20.5	--	D. S.	----
70	15 S.E. do	Louis L. Pharr	1929	152	5 3/16	----	104.2	4/5/38	D. S.	Weak [illegible]
71	14½ S.E. do	do	do	210	6¼	----	78.9	do	S.	do
72	16 S.E. do	do	1937	190	8¼	Anacacho	76.2	do	S.	----
73	15½ S. E. do	do	do	500	--	----	--	--	--	No water; [illegible]
74	16½ S. E. do	do	do	300	--	----	--	--	--	[illegible]
83	---	R. R. Martin	[illegible]	[illegible]	8		Flow[illegible]	--	[illegible]	[illegible]

Water
Filco

Well

Gas T

Casing
118'-

140'-

Fold-out Placeholder

This fold-out is being digitized, and will be inserted at a future date.

Location		Owner	[illegible] [illegible] rig.	Remarks
mi. N.W. of Crystal City		Bunter Hardy		Flowed in 1924
0 mi.N.W.	do	do		Ceased flowing 1924
5	do	do		
o	do	do		
0	do	do		Probably Bigford
mi. N.W.	do	J. H. Rhoads		203'-12½";305'-8½";308'-6 5/8
	do	Gunter Hardy		
o	do	do		Salt-Bigford @ 180
mi. N.W.	do	D. M. Carr	77	
s	do	L.M. Davenport	50	264'-10"; 536'-8"
mi. N.W.	do	Franklin Rutle	25	254'-10"; 383'-8";185'-6 5/8"
o	do	do		
	do	Scott Pegues	110	251'-10"; 390'-8";147'-6 5/8"
	do	do		360'-4"; 180'-3"
o	do	Archie Carr	50	262'-8"; 280'-6 5/8";185-6 5/
e	do	Mayberry	57	360'-4"; 180'-3"

USDA

Fold-out Placeholder

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Fold-out Placeholder

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Fold-out Placeholder

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APPENDIX II

Maps